Experiment is first to simulate warming of Arctic permafrost

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Although vegetation growth in the Arctic is boosted by global warming, it's not enough to offset the carbon released by the thawing of the permafrost beneath the surface, University of Florida researchers have found in the first experiment in the Arctic environment to simulate thawing of permafrost in a warming world.

Twice as much carbon is frozen in Arctic permafrost as exists in the atmosphere today, and what happens to it as it thaws – releasing greenhouse gases that fuel climate change – is a key question, said professor Ted Schuur, who heads the Permafrost Carbon Network and the Ecosystem Dynamics Research Laboratory in the UF department of biology.

Schuur, postdoctoral researcher Susan Natali and their team report the results of the three-year study in the journal *Ecology*, released this week online.

"The plants like it when they're warmer, so their growth is increasing, and if you just watch the tundra in the summertime and you look at the balance between what the plants are doing and what the soil is doing, the plants actually offset everything that happens in the soil. They're growing faster, getting bigger and taking carbon out of the air," Schuur said. "From the perspective of climate change, that's a good thing, tundra vegetation is making up for any carbon you're losing from the soil."

The hitch? The Arctic's short summers do not make up for the long winters.

Researchers are interested in the permafrost of the polar regions because these soils – permanently frozen at great depths and for tens of thousands of years – are vulnerable to global warming.

"We continued to measure emissions in the winter, and what happens is the plants are shutting down, they're dormant, but the microbes continue to eat the soil, and it turns out that they release enough carbon during the winter to offset everything the plants gained in the summer, and possibly even more," Schuur said.

As the experiment continues into the next three-year cycle, Schuur said he is looking for a point at which the plants hit a growth limit and stop absorbing more carbon, while the thawing permafrost continues to release carbon.

Scientists estimate that 20 to 90 percent of the organic carbon pool in permafrost can be decomposed by microbes, converting it to greenhouse gases that warm the atmosphere. The warmer atmosphere causes additional thawing, creating a cycle that gets warmer and warmer.

For the study, the research team built snow fences to create snowdrifts in the winter to warm the soil of the Alaskan tundra beneath.

"This will be interesting for Floridians, but if you catch a whole bunch of snow in a giant pile, that actually keeps the tundra warmer than it would be," Schuur said. "It's like a giant blanket that insulates the tundra soils from the cold air."

The extra snow, however, would cause an artificially late spring, and the research team needed to measure typical spring warming.

"So we go up to Alaska and shovel all these drifts of snow away in April," Schuur said. "Alaskans think it's crazy."

One of the successes of the experiment, Schuur said, was finding a way to model carbon release from permafrost in the environment on a year-round basis. Previous studies had used miniature greenhouses in summer months, but creating a warming situation in the winter was more challenging.

"We wanted to warm the tundra and cause the permafrost to recede. This is the first experiment to isolate that effect in the field, so the first thing we show is that we're able to simulate what will happen in a future world when the permafrost degrades," Schuur said.

Laboratory experiments, too, remain vitally important, Schuur said. A recent study in Nature Climate Change in which Schuur participated, examined 12 years of permafrost samples, an unusually long time frame for such studies. The research showed that the water content of the samples – whether the soils drained or remained waterlogged – had a large effect on how much carbon the soils released, with well-drained soils releasing more carbon.

And in a recent report in Global Change Biology, Schuur and postdoctoral researcher Christina Schadel synthesized the data from sites across the Arctic Circle, as part of the Permafrost Carbon Network, started at UF by Schuur with a National Science Foundation grant. That study showed that the ratio of carbon to nitrogen in permafrost soils helps determine how much carbon the soil releases upon thawing. The ratio could be a useful tool in ecosystem modeling because the ratio could be measured in any soil sample.

The studies confirm that a significant amount of carbon is released from thawing permafrost and highlight that there are factors beyond simply temperature that affect carbon release, Schuur said.

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